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A test of the utility of Central Place Theory in archaeology

Much analysis of archaeologically known settlement patterns has dealt with the effects of environmental factors on site location. Of these factors, resource localization has perhaps been most emphasized. Differential distributions of floral and faunal food resources, and of organic and inorganic raw materials, have been associated with differential site locations. This man-land approach has been highly productive, especially when dealing with cultural systems of relatively low complexity. I would suggest however that when dealing with systems of greater complexity, man-man relationships take on increasing importance in the determination of the spatial distribution of activity loci and thus of settlements. In emphasizing basically economic man-man relationships, Central-Place Theory furnishes a potentially useful analytical model for dealing with these systems. In the present paper the utility of certain aspects of Central-Place Theory in the analysis and interpretation of archaeological settlement pattern data is tested. The Early Dynastic I (E.D.I) settlement pattern from the Diyālā Plains, Iraq (*c.* 2800 B.C.) is used as a test case. The application of a central-place model to these data will be considered useful if it leads to the formulation of new, potentially important, and archaeologically testable hypotheses relative to the operation of processes resulting in the observed settlement pattern.

In his initial formulation of Central-Place Theory, Christaller proposed ways in which a settlement system associated with a modern market economy could be spatially organized to perform certain types of work most efficiently[1]. This work involved the production and distribution of goods and services. Briefly, in a settlement system organized according to Christaller's "Market-ing Principle" central places or towns of the same functional size are equi-distant from one another and when most efficiently located have a hexagonal distribution. Each town serves a surrounding, hexagonally shaped com-plementary region. Smaller central places and associated complementary regions may be hierarchically nested within this system to form an intricate settlement lattice.

Within Christaller's model, the form of this lattice may be altered under

B.C.) see now Drerup, H. (1969). Griechische Baukunst in geometrischer Zeit, *in* Matz, F. and Buchholz, H.-G. (eds.) *Archaeologia Homerica.* Gottingen, II o, Vallet, G. and Villard, F. (1969). Mégara Hyblaea IX. Les problèmes de l'agora et de la cite archaïque, *Mélanges Ec. Fr. Rome*, 81.

13 For the opposition between mountainous frontier territory as "bush", and cultivated land see Vidal-Naquet, P. (1968). The Black Hunter and the origins of the Athenian ephebeia, *Proc. Camb. Philol. Soc.*, 14 (French text *Annales* (*ESC*), 23), Vidal-Naquet, P. (1970). Grèce. Une civilisation de la parole politique, *in Encyclopaedia Universalis*, 7, Paris.

14 *Laws* 778d–779a, with a reference also to the fortification of frontiers. On Greek warfare, fortifications, etc. see Vernant, J.-P., (ed.) (1968). *Problèmes de la guerre en Grèce ancienne.* Paris. On early city walls Drerup, H. (1969). *op. cit.* Fortifications may have played a greater part in Mycenaean warfare.

15 Aristotle, *Politics*, 1331a 30 ff. Note also that the beginning of structural differentiation of law from politics made it possible to treat litigiousness as an urban vice (Aristophanes; Polybius, IV.73. 6–10), and often to associate it closely with commerce.

16 Momigliano, A (1944) Seapower in Greek Thought, *in* Momigliano, A. (1960). *Secondo Contributo.* Rome.

17 Lammermann, K. (1935). *Von der attischen Urbanitat und ihrer Auswirkung in der Sprache.* Diss. Gottingen, Ribbeck, O. (1888). Agroikos, eine ethologische Studie, *Abh. Kgl Sachs. Ges. d. Wiss.* (ph.-h. Cl), 10, pp. 1–68.

18 See further Humphreys, S. C. (1970). Economy and society in classical Athens, *Annali Scuola Norm. Pisa*, 39. The urban/rural boundary did not coincide with the opposition between rich and poor even when upper-class Athenians attempted to separate hoplites from sailors. The political philosophers' idea of the peasant proprietors as a "middle class" (Mossé, C. (1962). *La fin de la démocratie athénienne.* Paris. pp. 247–53) was based on the traditional identification of citizenship and the right to own land. Aristophanes' frequent play on the urban/rustic contrast belongs mainly to the years when the rural population of Attica was evacuated to the city, and is cultural rather than political; on the false picture of Aristophanes as champion of a conservative peasantry see Gomme, A. W. (1938). Aristophanes and Politics, in Gomme, A. W. (1962). *More Essays in Greek History and Literature.* Oxford.

19 See Nicholas, D. M (1969). Medieval urban origins in northern continental Europe: state of research and some tentative conclusions, *Stud. Mediev. Renaissance Hist.*, 6.

20 e.g. Ward-Perkins, J. B., this volume, pp. 867-82.

21 For the *chōra* of Alexandria see Jones, A. H. M. (1940). *The Greek City from Alexander to Justinian*, Oxford. p. 20.

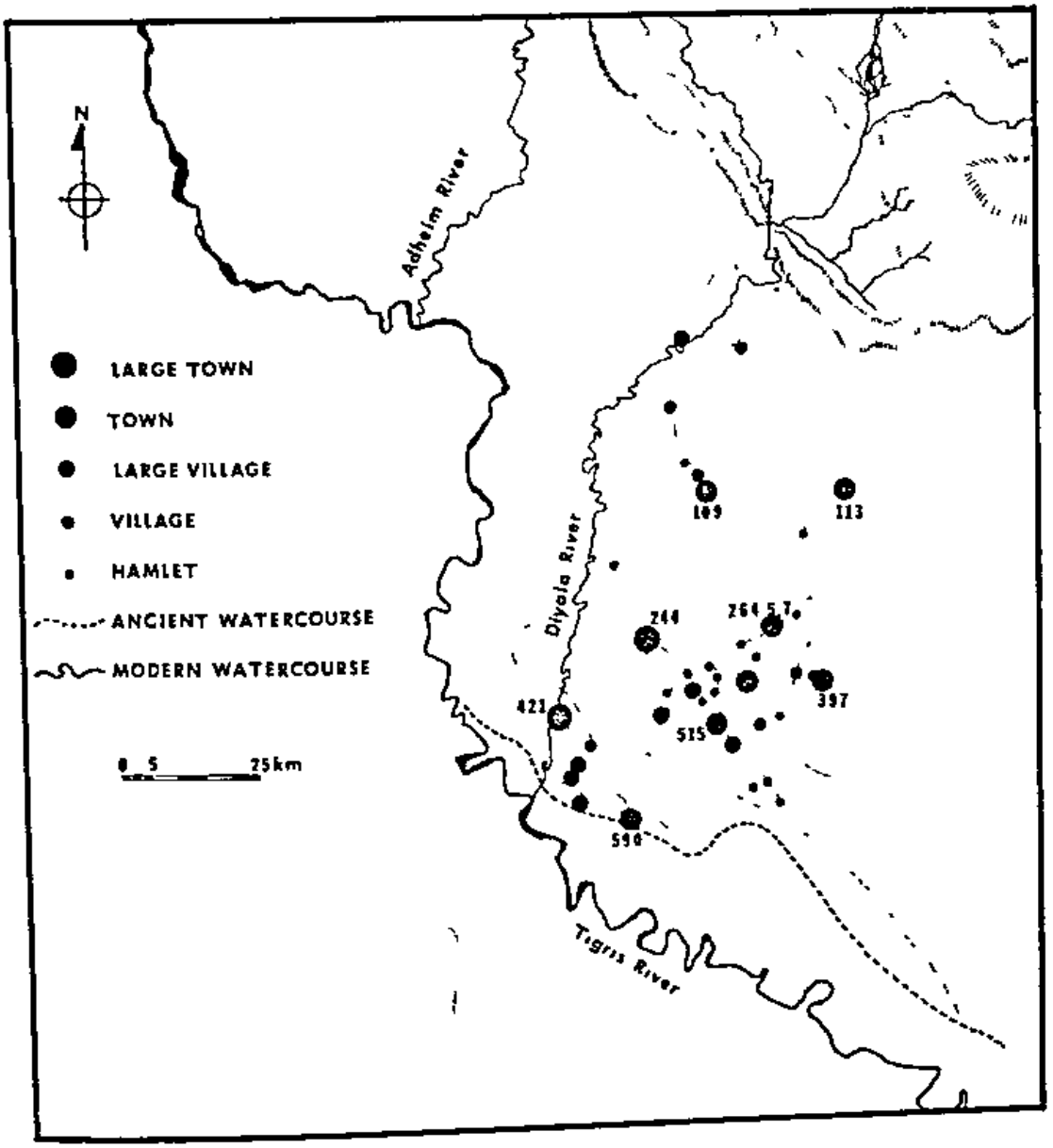


Fig 1 Early Dynastic I settlement pattern. Diyālā Plains, Iraq.
(After Adams, R. McC. (1965). *Land Behind Baghdad: A History of Settlement on the Diyālā Plains*. Chicago and London.)

The model used in this paper and the proposed E.D.I settlement lattice are presented in Figs. 2 and 3.

Most central place studies have concentrated on hexagonal distributions, although rhomboidal patterns have been noted[6]. The roughly parallel paths of major watercourses in the Diyālā were apparently responsible for the rhomboidal distribution which seems to occur there. Thus for present purposes, Christaller's distributions have been adapted to a rhomboidal model.

This model consists of four lattice cells. A cell is defined as the complementary region of a central place of highest order in the system. The corners of each cell are defined by a distribution of four "town" size settlements.

These are: a town level, in which a large town serves as a central place for surrounding towns; a large village level, in which a town serves as a central place for surrounding large villages; and a village-hamlet level, in which a large village serves as a central place for surrounding villages and hamlets.

Derivation of the proposed lattice is illustrated in Fig. 2 A-F. Fig. 2A presents the model lattice. Fig. 2B indicates sites which due to their truncated complementary regions might be expected to be smaller than predicted by the model. Fig. 2C illustrates the locations of observed sites relative to site locations predicted by the model. Fig. 2D indicates deviation of observed from predicted site size in terms of the five level hierarchy. Filled circles represent an accurate size class prediction. A half-filled circle indicates that a site is larger than predicted. "Most reasonable" connectivity lines are retained. Fig. 2E introduces deviations in relative site to site distance from that predicted by the model[9]. Additional connectivity lines (dashed) are added on a subjective basis. Fig. 2F represents the proposed lattice. Fig. 3 presents an enlarged version of this proposed lattice with site reference numbers indicated.

Having derived the proposed settlement lattice through a less than rigorous procedure, an initial quantitative evaluation of similarity or dissimilarity between the model and the proposed lattice is required. The model was primarily constructed on the basis of theoretical transport considerations. Relative success of the model in predicting relationships within the proposed lattice would provide evidence for the operation of similar processes in the Diyālā. The following procedures test the fit between the observed distribution of site sizes, and the distribution predicted by the model.

(i) Each site was assigned a category rank from 1 to 5 on the basis of its position in the proposed functional settlement hierarchy. Large towns were assigned rank 1; towns, rank 2; large villages, rank 3; small villages, rank 4; and hamlets, rank 5. (ii) Each site was assigned a second category rank based on its hierarchical position predicted by the model. (iii) A Kolmogorov-Smirnov non-parametric one-sample test was performed to compare the observed and predicted cumulative site size category rank distributions. (iv) A parametric product-moment correlation coefficient (Pearson's r) was calculated for the observed and predicted site size-category rank distributions. (v) The analysis was repeated for each of the three major cells of the proposed lattice. This allows evaluation of possible differences in fit for major lattice components.

Sample sizes for various aspects of this analysis were determined by the number of settlements in each cell of the proposed lattice. These cells are defined from the model as follows. The Tutub cell, named after the ancient town of Tutub (site 421), containing the following sites; 421, 244, 515, 590, 568, 462, 355, 359, 458, 450, 362, and 357. The Eshnunna cell, named after the ancient town of Eshnunna (site 244), containing the following sites: 244, 515, 397, 264-5, 7, 366, 355, 396, 517, 372, 362, 259, 381, 364, 341, 262, 344, and 350. The Northern cell, contains the following sites: 244,

"Large villages" are located on cell boundaries, equidistant from each pair of towns This distribution follows Christaller's transport principle[7].

Application of the marketing principle to this transport lattice results in the location of a "large town" at the centre of each cell, serving as its central place. The model hierarchy is expanded from three to five levels by the addition of village and hamlet size settlements. These settlements are distributed so that hamlets are located at mid-points between villages; and villages are located at midpoints between large towns and large villages, towns and large villages, and pairs of large villages. Settlements of the same size do not form reflexive nearest neighbour pairs. Three of the five levels of the model hierarchy were suggested by the size distribution of identified E.D.I settlements. (See Fig. 4.) The distinction between hamlets and small villages was made on locational grounds in the course of the analysis and seems to be valid. The following size classes are suggested. large towns—over 15 ha in area; towns—between 6 and 15 ha; large villages—between 3 and 5 ha; villages—between 1 and 3 ha; and hamlets—less than 1 ha[8].

The five level model lattice incorporates three levels of subsystem nesting.

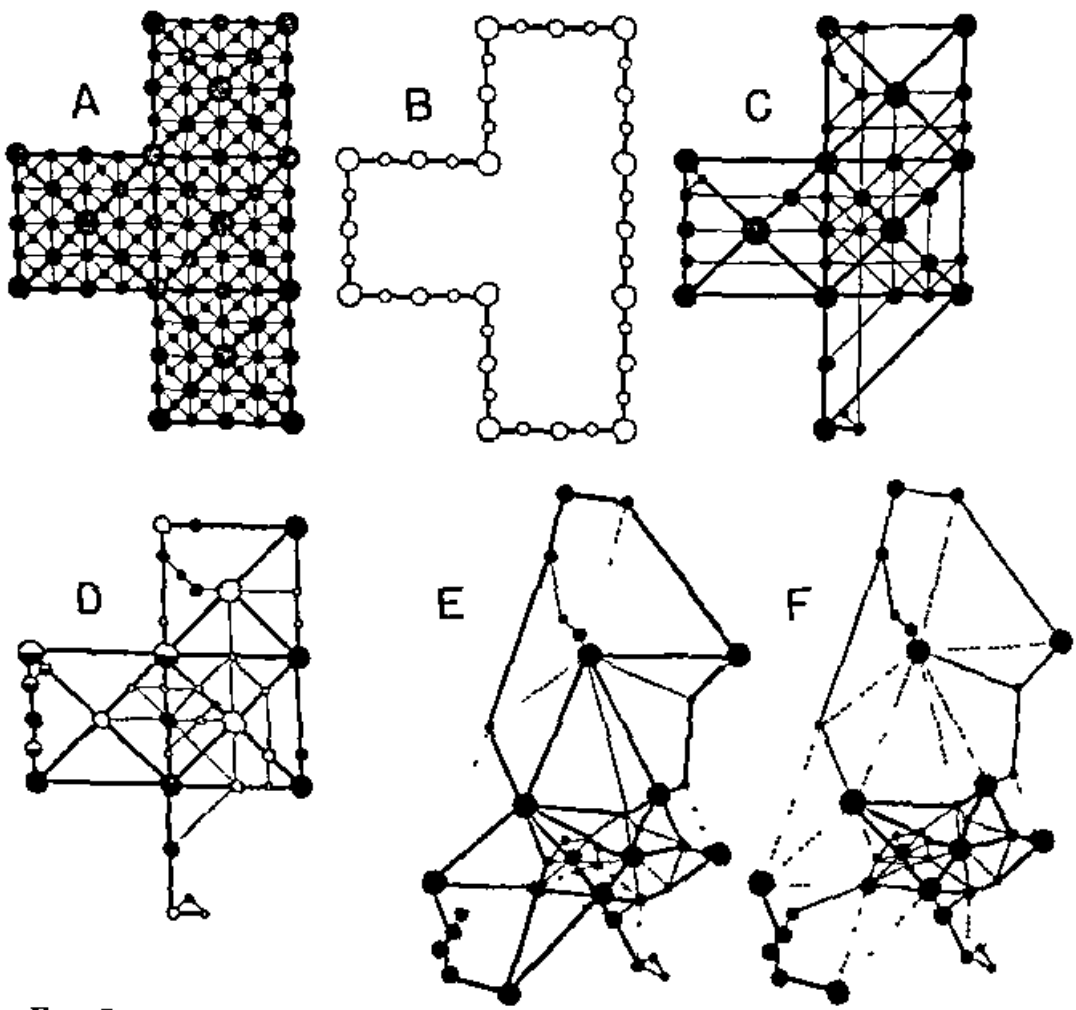


Fig 2 Derivation of the proposed settlement lattice.

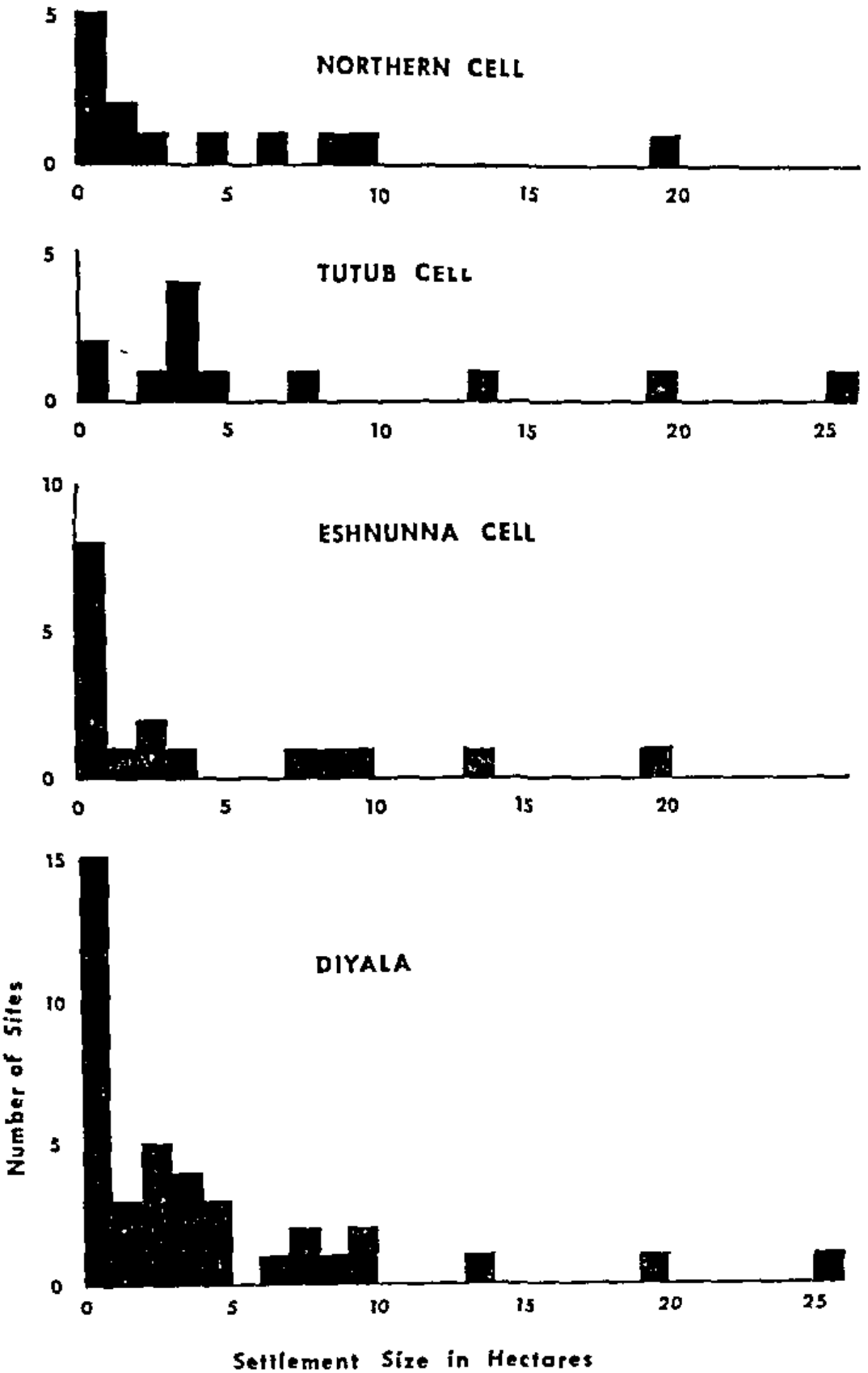


Fig 4 Histograms of settlement size.

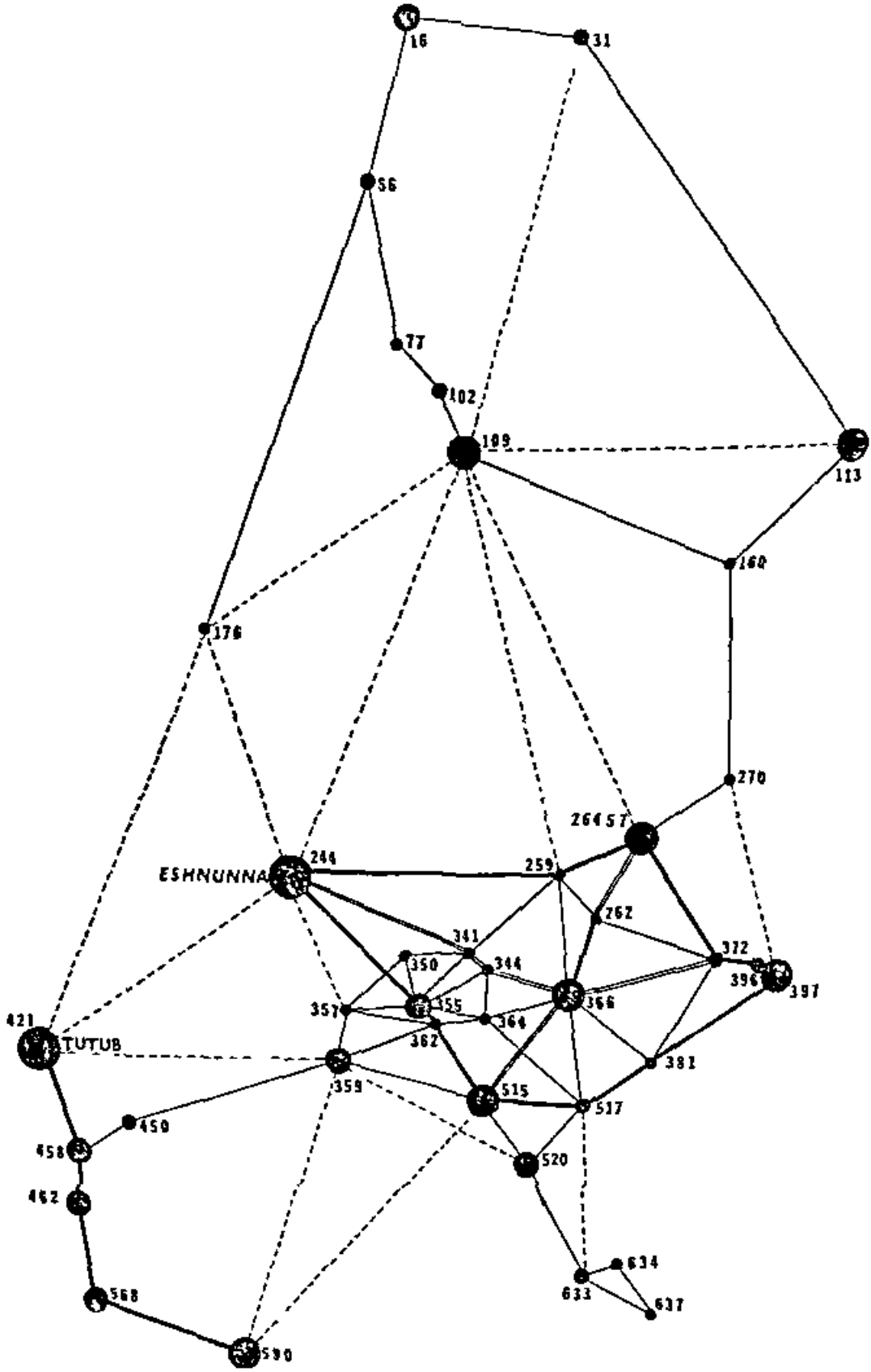


Fig 3 Diyālā Plains, Iraq. Early Dynastic I. Settlement lattice.

mately ·10 and ·15 respectively are not sufficient for the null hypothesis of no significant difference between the observed and predicted distributions to be rejected.

The Eshnunna cell is the most complex area of the Diyālā. Increasing complexity may be associated with increased deviation in the distribution of size values from the predicted distribution. This reflects upon the power of the present model to predict size distributions in complex situations. Deviations for the Diyālā as a whole appear to be largely a function of deviations in the Eshnunna cell.

Despite these deviations, a generally good fit is indicated between the size distributions of the model and the proposed lattice. This suggests that processes analogous to those postulated by Christaller's transport principle may have been operative in the Diyālā during the E.D.I period.

Moving to a more detailed consideration of individual lattice cells, certain statistical regularities may be noted in the distribution of small settlements within the Eshnunna cell. These regularities seem to support the contention that the lattice reflects the operation of transport considerations on settlement location.

Fig. 5 indicates one component of the positional deviation of nine small villages and hamlets from their predicted positions on the paths of shortest straight-line distances connecting the five towns of the Eshnunna cell. This deviation is indicated by a line originating at the actual position of each village or hamlet and terminating at its perpendicular intersection with the shortest distance path between two towns.

These deviations were measured in millimetres from the map and correlated with the areal sizes of the nine associated settlements. With all nine site sizes and positional deviations included, a correlation coefficient of ·41 was obtained. This value does not reach even the .05 significance level. Inspection of the scatter plot of the data reveals that one site (396) has a considerable effect in lowering the coefficient obtained. 396, a "small village" of 2·06 ha is located very close to a town size settlement (397). The proximity of 396 to this town suggests that they are in some special relationship, or perhaps are the same settlement. If 396 is deleted from the analysis a coefficient of ·81 between site size and positional deviation is obtained. This is significantly above the .05 level. Connectivity lines between towns show deviation from their expected straight line paths in direct proportion to the sizes of the villages or hamlets located on these lines. If these connectivity lines are interpreted as rough transport routes, it is evident that greater effort is made, in terms of distance travelled, when these routes pass through larger villages and hamlets than through smaller settlements. Note that in general deviations from expected site location are greater on the periphery of the cell than in the interior.

The analysis thus far has considered only villages and hamlets located on connectivity lines between towns. If all such settlements are considered, the

109, 264–5, 7, 113, 16, 59, 31, 102, 160, 176, 259, 77, 270. The fourth cell is defined as those settlements lying south of the Eshnunna cell. Only four settlements occur in this area, and for this reason the cell was eliminated from this portion of the analysis.

The analysis measures the extent to which site size-category ranks of the proposed lattice are predicted by those of the model. Table 2 summarizes the results of this analysis.

I Kolmogorov-Smirnov one-sample test

D = maximum $|F_e(X) - S_e(X)|$

Where D — the test statistic
$F_e(X)$ = the predicted cumulative frequency distribution
$S_e(X)$ = the observed cumulative frequency distribution
$F_e(X) - S_e(X)$ — the deviation distribution

D values and associated probabilities

	D	N	P approx.
1 Diyālā	282	39	01
2 Eshnunna Cell	412	17	01
3 Tutub Cell	333	12	·10
4 Northern Cell	308	13	15

II Product-Moment correlation

$$r = \frac{xy}{\sqrt{(x^2)(y^2)}}$$

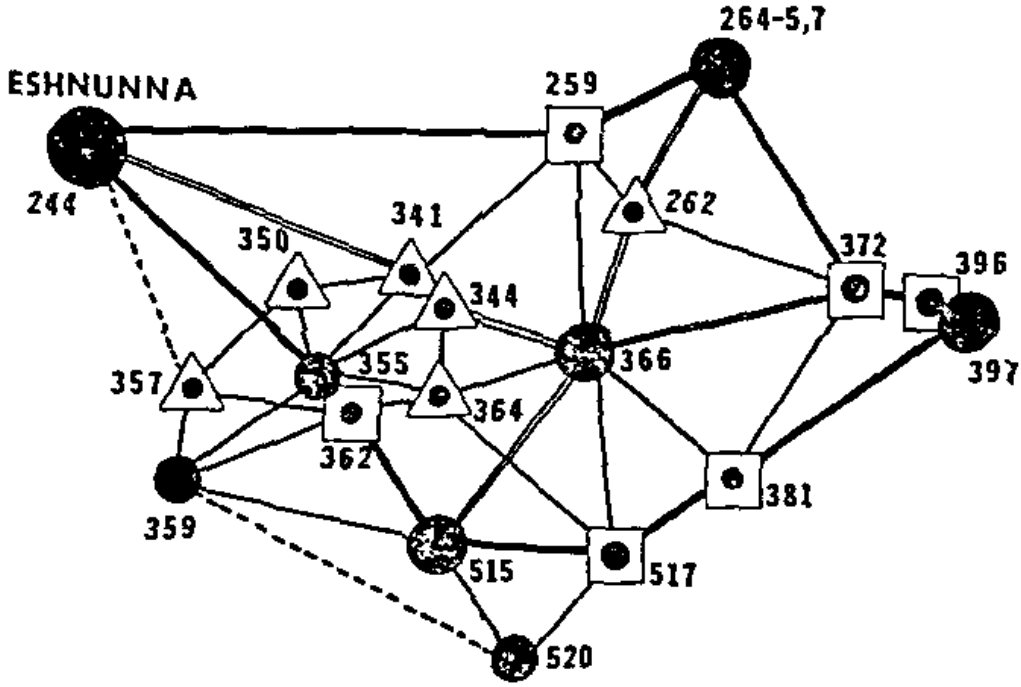
Where, r — the test statistic
x — predicted size-category ranks
y = observed size-category ranks

	n	r	R	df	P
1 Diyālā	39	952	·901	37	01
2 Eshnunna Cell	17	968	·937	15	01
3 Tutub Cell	12	941	885	10	01
4 Northern Cell	13	976	953	11	01

Table 2 Comparison of observed and predicted settlement sizes by size category[10].

The product-moment correlation analysis shows a close relationship between the observed and predicted category rank distributions for the lattice as a whole, and for each of its three major cells. The coefficients obtained range from 0 94 to 0 98 and the proportion of variance explained ($R = r^2$) from 88% to 96%. In all cases the probability that the coefficients obtained are due to chance is less than 0 01. All coefficients are accepted as significant and the null hypothesis that the observed and predicted distributions are significantly different is rejected.

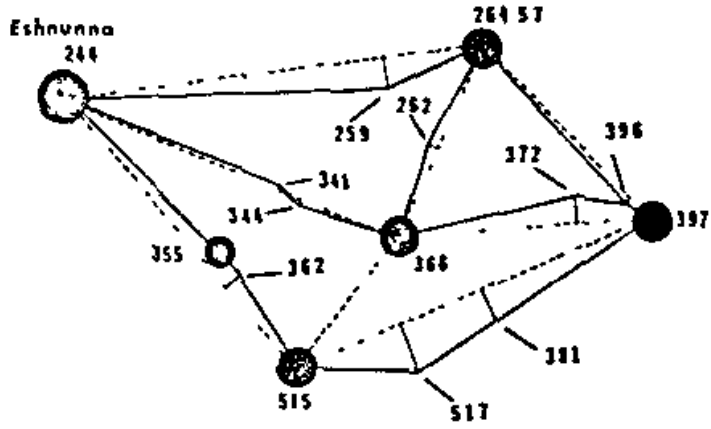
The results of the Kolmogorov-Smirnov one-sample test are slightly different from those obtained from the correlation analysis. For the Diyālā as a whole and the Eshnunna cell, the maximum deviations of the observed from the predicted cumulative frequency distributions are significant at the ·01 level. For the Tutub and Northern cells, probability values of approxi-



Group 1			Group 2		
Rank	Site	Size	Rank	Site	Size
1	396	2.06	7	364	.74
2	517	2.01	8	341	.72
3	372	1.47	9	262	.50
4	362	.91	10	357	.20
5	259	.84	11	344	.17
6	381	.79	12	350	.13

Fig 6 Eshnunna enclave. Definition of primary connectivity lines.

The central town of the system (366) does not appear to function fully as the focus of interaction for the cell. This situation might have come about as follows. During the Early Dynastic I period the lattice proposed for the Eshnunna cell was in the process of development. Initial major settlements in the area appeared along two major watercourses or branches thereof. To the east, one watercourse connected Eshnunna (244) and Tell Asmar (515). To the west, the second major watercourse connected Tulūl Dhibaʿi (264–5,7) and Abū Yiwālik (397). Smaller settlements along these watercourses probably appeared at approximately the same time as the larger settlements. Increasing integration of the activities of the four towns led to the settlement of new sites favourably located for the mediation of this interaction. A town, Tell Sebʿe (366) appeared at a position roughly equidistant from the four



Case	Site	Size	Deviation
1	517	281	175
2	381	79	125
3	259	84	108
4	372	147	95
5	362	91	65
6	262	58	48
7	346	17	28
8	396	206	20
9	341	72	15

Regression

1—All Cases	2—Case 8 Deleted
N=9	N=8
r =41	r =81
R =17	R =66
df=7	df=6
P >05	P <05

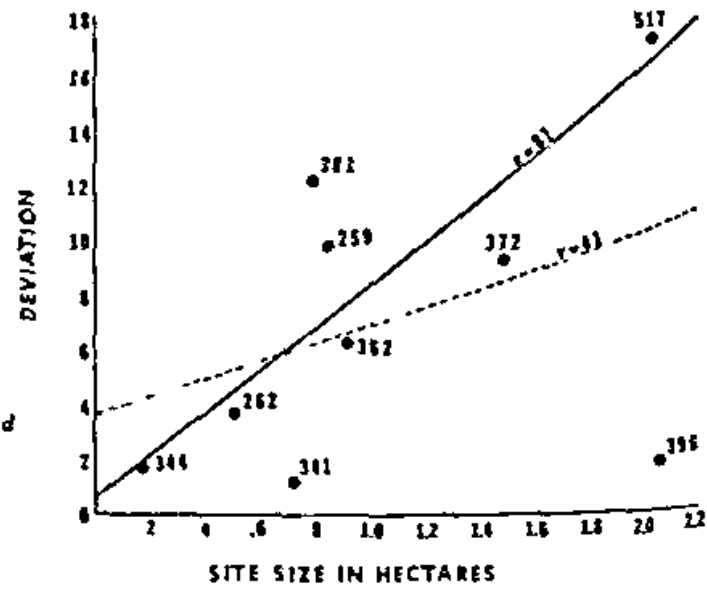


Fig 5 Eshnunna enclave. Relationship of village size to deviation from expected location.

sample size is increased to twelve. This sample was divided into two groups based on settlement location. Group 1 consists of sites located on connectivity lines linking the four peripheral towns of the system. Group 2 consists of sites located off these lines. Stratified in this way settlements of Group 1 are consistently larger than those of Group 2. (See Fig. 6.)

If site size is taken as a measure of settlement importance, the relative importance of connectivity lines may be associated with the relative size of settlements located on these lines. This suggests that the primary connectivity lines of the Eshnunna cell are those between its four peripheral towns. Lines passing through the central town (366) are less important.

If the interaction, economic or otherwise, among the five towns of the area were uniform, the connectivity lines among these towns would be expected to be of roughly equal importance as reflected by the importance (size) of the lesser settlements located along these lines. As this is not the case, it is suggested that interaction was not uniform throughout this system.

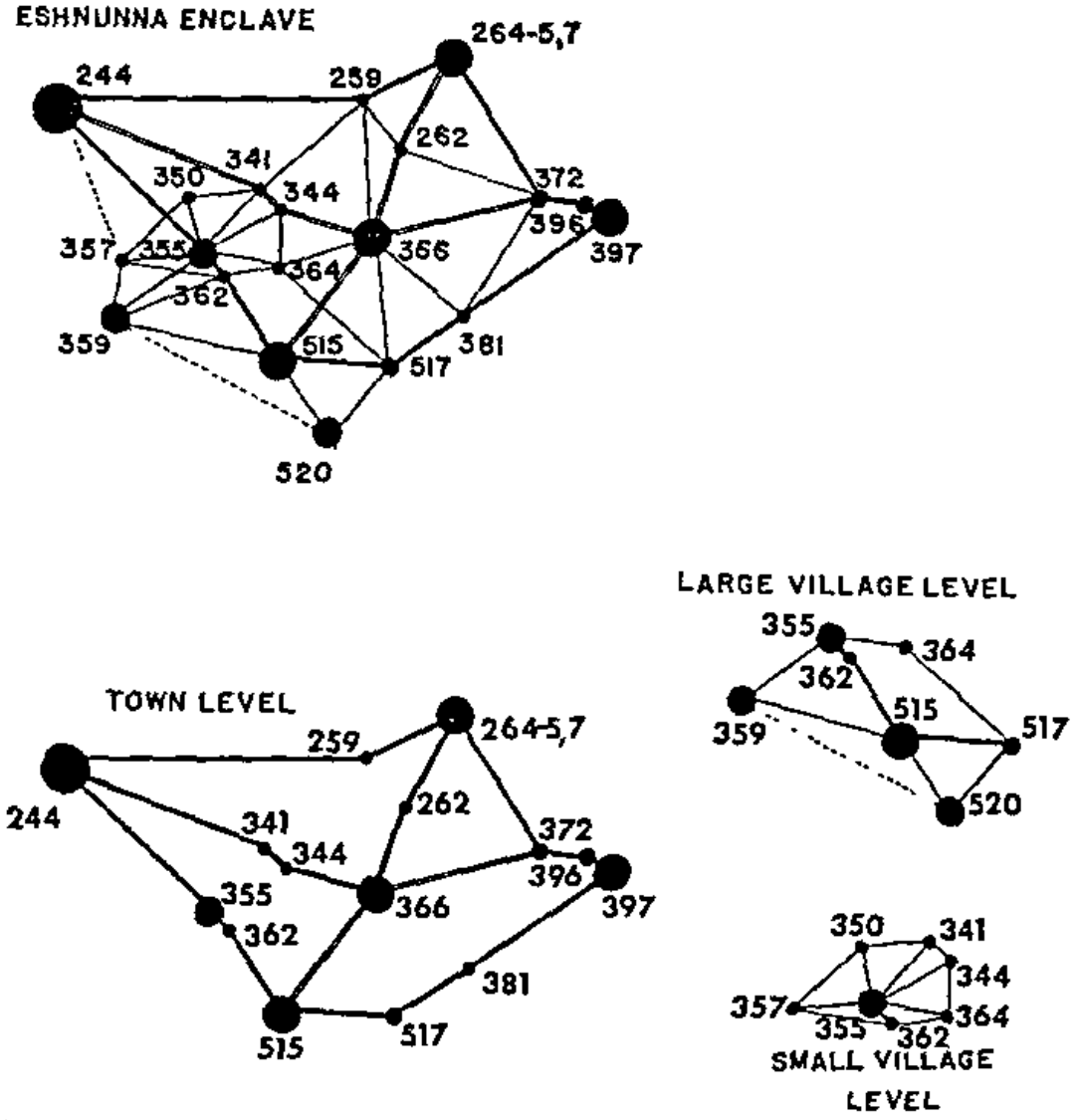


Fig 7 Subsystem nesting. Eshnunna enclave.

this "enclave" and the Eshnunna area. This is perhaps the most intensively surveyed area of the Diyālā. It has been suggested that silting and levee formation from the late Narawān canal which passes through this area may have obscured evidence of local settlement. Adams feels however that deposition from this source had little effect in masking evidence of settlement in this area[12]. Much of the area is simply devoid of Early Dynastic I settlement.

This has led to the hypothesis that some sort of political boundary lay between Tutub and Eshnunna and their associated settlements. The area would then be interpreted as a buffer zone between two antagonistic states. At present there is little evidence bearing on this question. Preliminary examination of published artefactual material from Tutub and Eshnunna gives no indication of stylistic differences which might be indicative of minimal or reduced contact between these areas.

The large village (359) located in the interior of the proposed Tutub cell is particularly interesting. If Tutub and Eshnunna were the administrative

earlier towns. Smaller settlements (344, 341, 262, and 372) were founded at sites very close to the shortest straight line paths leading from the four earlier towns to Tell Seb^{c}e. The placement of these smaller settlements suggests that they were located primarily for transport considerations. This placement, in conjunction with the results of the preliminary goodness of fit tests between the model and the proposed lattice, lends considerable support to the hypothesis that transport considerations played a large part in the determination of settlement location

Chronological relationships in the sequence of settlement are a major factor in this reconstruction. They may be tested, in part, with secondary data available from Adams' survey. It is predicted that of the five towns of the area, four (244, 515, 264-5,7 and 397) should show evidence of earlier settlement than the central town of the system (366). On the basis of material from Adams' surface collections, this is the case[11]. The reconstruction also predicts that certain small villages and hamlets should have been settled earlier than others Sites 259, 362, 381, 396, and 517 should be generally earlier than 262, 341, 344 and 372 Of the first group, 396 and 517 were probably first settled in the Ubaid and were occupied (perhaps intermittently) through E.D.I. Of the four sites predicted to have later initial occupations, three were settled during E.D.I, and one shows evidence of an Ubaid occupation The prediction of relative chronology of villages and hamlets is thus partially borne out by secondary data.

Locational relationships among the towns of the Eshnunna cell have been discussed as an isolated system. It appears however to be a subsystem, the upper level of a central-place hierarchy in the area. Two additional nested central-place subsystems may be proposed. (See Fig. 7.)

A large village subsystem includes three large villages (359, 355, and 520); three small villages and hamlets (362, 364, and 517); and one town, Tell Agrab (515). A small village (517) is located at a position predicted for a large village. At 2 01 ha however, it is one of the larger settlements of its size class. Tell Agrab is in a position and of a size to indicate a central-place function for this subsystem Large villages 359 and 520 are located outside the proposed Eshnunna cell but are apparently included within its central-place hierarchy.

A small village subsystem includes six small villages or hamlets (350, 341, 344, 362, 364 and 357); and one large village, Tulūl Shilbiyat (355). Site 355 is indicated by its position and size to have functioned as a central-place for this subsystem.

In summary, the Eshnunna area seems to have had a highly complex locational structure, determined to a significant extent by "transport" and "marketing" considerations and including hierarchically nested central-place subsystems.

Tutub (421) and the sites which lie to the south in a generally linear fashion have usually been described as a settlement enclave[12]. The apparent isolation of these settlements results from the virtual absence of sites in the area between

would be expected. Adams reports that after prolonged search only Early Dynastic materials were found on Abū Rasain (109). Evidence of a defensive wall and ". . . greater quantities of worked flint of all kinds than have ever been encountered by the author on an alluvial site" are also reported[18]. Jacobsen, as reported by Adams, visited Abū Salabikh (113) the other town size settlement of the northern area. Again only Early Dynastic materials were found, with "many large unworked stone blocks . . ."

The presence of these concentrations of raw materials associated with large E.D.I settlements supports the hypothesis that sites of the Northern cell served as mediation points in the importation of these raw materials. Available evidence also supports the hypothesis that population expanded into the northern area from the south. Adams notes that, "Ubaid farmers entered from, or at least had their primary affiliations with, areas farther south in the Tigris-Euphrates flood-plain"[20]. This suggests that the southern Diyālā was occupied first, with subsequent northern expansion.,

The fourth proposed lattice cell remains to be discussed. It contains only four sites, located south of the Eshnunna cell. These include a small village (633); two hamlets (634 and 637); and a large village (520). 520 has been associated with the large village subsystem of the Eshnunna area. These four sites may represent a budding off phenomenon: an initial stage of population expansion from the Eshnunna cell. Possibly they represent an entry point into the Diyālā for materials from further south. Additional data are required to test such hypotheses.

Central-Place Theory postulates regular spatial patterns of the differential distribution of activities related to the production and distribution of goods and services. In theory activity loci are so distributed that energy expended in these activities is minimized. In practice it appears that energy output minimization need not be assumed as necessary for the appearance of spatial distributions predicted by the theory.

In the present paper, the distribution of Early Dynastic I settlements in the Diyālā, and by implication activities, has been shown to approximate distributions predicted by various aspects of Central-Place Theory. The presence of such distributions need not imply that they are in whole or in part the result of the operation of processes postulated by the theory. A different set of ordering principles may be reflected in the observed distributions.

For example Adams has pointed out that on the basis of textual evidence overland transport was minimal in the Diyālā in the Early Dynastic period[21]. This would suggest that either the interpretation of the present analysis is basically in error, or that overland transport was more significant and/or intense than present evidence would indicate. The present analysis should in no way be construed as providing even a partial explanation of settlement locations in the Diyālā. It does, however, provide a series of hypotheses relative to the operation of processes which may have contributed to the determination of settlement locations. Further data on differential activity

centres of rival and perhaps antagonistic political systems at this period, this village might have served as a locus for the mediation of peaceful economic and political contact between them. Although incorporated into the structure of the Eshnunna area, the settlement may have functioned as a "port of trade" of the sort suggested by Polanyi[14].

In the present analysis the Tutub and western portion of the Eshnunna areas are linked forming the Tutub lattice cell. Even if a boundary of the sort suggested by Christaller's administrative separation principle existed between these areas, they probably would not have been isolated from one another in a systemic sense. Some political and economic contact would have taken place between them The proposed Tutub cell represents the possible locational aspects of this contact, and links the Tutub area into a general locational system of the entire Diyālā. The proposal of a Tutub cell was suggested by the uniform distribution of its four major settlements (241, 244, 515, and 590).

The use of the Tutub cell as a unit of analysis is also supported by the results of the preliminary goodness of fit tests described above. A correlation coefficient of ·94 significant at the 01 level was obtained between the observed and predicted size category rank distributions. The Kolmogorov-Smirnov one-sample test revealed no significant difference between these distributions. All these factors suggest the utility of linking the Tutub and Eshnunna areas in the Tutub cell.

The distribution of settlements north of Tutub and Eshnunna has been described as a ". . . scatter of settlements of various sizes"[15]. In this analysis Abū Rasain (109) is identified as the central place of a Northern cell. The southern Diyālā (Tutub and Eshnunna cells) shows a considerably higher site density than does the north. The hypothesis is suggested that the Northern cell represents occupation of the area by a population expanding from the south. Two possible reasons for such settlement are suggested. One, to open new agricultural areas. The apparent availability of considerable unused agricultural land in the south suggests that this was not a major factor in the settlement of the northern area. Two, the northern area was possibly settled, in part, to establish centres to mediate the importation of raw materials from source areas in the Zagros to the area of primary population concentration in the southern plain.

The principal raw material resources of the Mesopotamian alluvium were soil, water and reeds. Most other materials had to be imported from other areas. Wright includes wood, bitumen, flint, copper, alabaster, and similar stones for vessels, and basalt and similar stones for grinding slabs among the principal bulk imports into the alluvium[16]. Lapis lazuli, carnelian, agate, and obsidian for lapidary purposes; gold, silver, and lead among other materials appear in smaller quantities[17].

As the Zagros was a primary source area for many of these materials, the existence of specialized centres for their importation into the Diyālā area

12 Wright, H. T. (1969). The administration of rural production in an early Mesopotamian town. *Anthropological Papers, Museum of Anthropology, University of Michigan No. 38*. Ann Arbor. p. 30.
13 Adams, R. McC. (1970) personal communication.
14 Dalton, G. (ed.) (1968). *Primitive, Archaic and Modern Economies: Essays of Karl Polanyi*. Garden City. p. 23 ff.
15 Wright, H. T. (1969). *op. cit.* p. 30.
16 Wright, H. T. (1969). *op. cit.* p. 31.
17 Delougaz, P., Hill, H. D. and Lloyd, S. (1967) Private houses and graves in the Diyālā region. *The University of Chicago Oriental Institute Publications, Vol. LXXXVIII*. p. 25 ff.
18 Adams, R. McC. (1965). *op. cit.* p. 139.
19 Adams, R. McC. (1965). *op. cit.* p. 140.
20 Adams, R. McC. (1965). *op. cit.* p. 36.
21 Adams, R. McC., this volume, p. 745.

distributions are required to test these hypotheses. These data must reflect activities and their organization both within and among the settlements of the area.

For example, the arrangement of settlements in the Eshnunna enclave suggests that nested central-place subsystems existed there in the E.D.I period. Material imported from outside the system would be expected to show a differential distribution among its three proposed levels. Raw materials may have been imported in large blocks to settlements of the highest level in the hierarchy, then subdivided for distribution to lower level settlements. Such subdivision might be expected to occur at each hierarchical level. In this case, the size and/or quantity of waste material from subdivision and artefact fabrication found on sites of different hierarchical position would be expected to be directly associated with these differential positions.

Though tentative and incomplete, the present analysis does indicate that Central-Place Theory and locational analysis in general may be a valuable aid in archaeological hypothesis formation. This type of analysis does not offer the archaeologist concerned with settlement systems a panacea for all his problems, but may make some of them less formidable.

Notes

1 Christaller, W. (trans. by Baskin, C. W.) (1966). *Central Places of Southern Germany*. Englewood Cliffs.

2 These assumptions are adapted from Garner, B. J. (1967). Models of urban geography and settlement location, *in* Chorley, R. J. and Haggett, P. (eds.) *Models in Geography*. London. pp. 304–5.

3 As the proposed model is based on a combination of transport and marketing considerations, it cannot be assigned a K-value.

4 Adams, R. McC. (1965). *Land Behind Baghdad: A History of Settlement on the Diyālā Plains*. Chicago and London. Additional data for this study were obtained from Dr. Adams' original survey notes which he very kindly made available to me. It should be pointed out that these data are known or suspected to be biased in several ways. At present little of this bias can be controlled. The reader is referred to Adams, R. McC. (1965). *op. cit.* p. 120 ff. for a discussion of these problems. Due to these biases, the results of the present analysis should be considered with caution.

5 This is most probably an erroneous assumption. It is however necessary due to the present lack of more detailed data.

6 Berry, B. J. L. (1967). *Geography of Market Centres and Retail Distribution*. Englewood Cliffs. p. 40.

7 Berry, B. J. L. (1967). *op. cit.* p. 79.

8 The sample size of E.D.I settlements used in this study is not sufficient to establish statistical modalities in their size distribution.

9 Due to the lack of appropriate data, distance transformations were not attempted in this analysis.

10 See Siegal, S. (1956). *Nonparametric Statistics for the Behavioural Sciences*, New York, Toronto, London, pp. 47–52, for a discussion of the Kolmogorov-Smirnov statistic. The use of Pearson's r is not strictly appropriate in this case, and should be considered here as a goodness of fit test.

11 Adams, R. McC. (1965). *op. cit.* p. 135 ff.